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Germline Engineering: Whose Right?

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Abstract.

Professor Cohen presents and analyzes a taxonomy of the potential harms of human genetic "germline engineering." Germline engineering is the process of "artificially" and purposefully changing the genes of an organism such that when it procreates the changes replicate themselves in the next generation and--subject to the laws of genetics—in all future generations. His ultimate argument flows from the outcome of the analysis of the various potential harms alleged to flow from germline engineering. While he finds that there may be minor categories that are problematic, these are no more than quirky--almost bizarre--exceptions to the central case, that is, that germline intervention will yield an enormous improvement in the human lot. Those exceptional instances in which one could imagine germline intervention resulting in harm to the human condition or prospect neither require nor justify any significant restraint or prohibition of germline intervention in general.

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Introduction.

The issue to which I will direct my attention in this essay is human 'germline engineering'. This term of art refers to the coming prospect of changing the genetic code of human embryos. There are many within the community of philosophers, scientists, 'medical ethicists' and laymen who oppose such tinkering. I do not; I relish the prospect. If there is some justification in prohibiting germline engineering it must rest on the evil or harm of the activity. I distinguish evil and harm to allow for the possibility that some action might fall in the first category (evil) while not falling in the second (harm), that is, that there is a moral dimension to human action independent of its effect--or intended effect--on other beings. But because as a lawyer and economist I can offer no special insight into evil, I will restrict my inquiry to harm.

My ultimate argument flows from the outcome of the analysis of the various potential harms alleged to flow from germline engineering. While I find that there may be minor categories that are problematic, these are no more than quirky - almost bizarre - exceptions to the central case, that is, that germline intervention will yield an enormous improvement in the human lot. Those exceptional instances in which one could imagine germline intervention resulting in harm to the human condition or prospect neither require nor justify any significant restraint or prohibition of germline intervention in general.

Some readers may agree in principle and yet still wonder whether at least regulation that might lightly brake the headlong rush of germline engineering might be prudent. Shouldn't we proceed at a more judicious pace? Consider the following observation about casualties in war. After a successful battle the official report states that casualties were light. For those who were killed, however, casualties were 100%. So too with germline intervention; for those who could be relieved of hideous suffering and early death by germline intervention delay means that they pay an almost unimaginable price, and more importantly a price that I will argue is not justified by any danger that is posed.

Genes and property.

The issue I address is the right to manipulate human genes. Genes, human genes in particular, exist only as expressed in actual living organisms. Those organisms and the genes they possess and express are a form of property. To describe something as property is

to imply a set of (property) rights that adhere to it. The question of the right to manipulate human genes is ultimately a question of property rights. Who or what have (or should have) rights with respect to human genes embodied and expressed in individual people? Let us begin by clarifying the scope and nature of property rights in general, and those in human beings in particular.

Property rights in human beings

Property is every 'thing' that people care to have rights with respect to. It is useful to think of the different sets of property rights that can and do exist as bounded by a triad, in which any particular property right must be some variation on a theme defined by the three endpoints of the triad. Those endpoints are: (1) private property - property with respect to which a single person has the right to exclude, use, and alienate, e.g., my apple; (2) communal property - property which everyone has an identical right to use and from which none have the right to exclude another or a power to alienate from himself, e.g., the air we breathe; and (3) collective property -property which some political body has the right to alienate, exclude, and define the set of permitted uses and terms of access, those uses and terms may be as limited and quasi-private as those of the space shuttle Atlantis or as broad and quasi-communal as state forests.

A property right need not be purely communal, or perfectly private, or wholly collective. It may partake of some of each category. But, out of logical necessity, it cannot extend beyond the boundary of the triad. That is, rights to exclude must be either private, or collective, or non-existent; permitted uses must be determined either collectively, privately (subject to collective constraints), or not at all; and rights to alienate must be either private, or collective, or non-existent. Every legal system and its defenders recognize some of each category of property. They differ merely as to proportion and detail, which is more than enough to drive men to the barricades.

What of the human body? Where does it lie in the triad? In the modern world, probably the single most universal, uncontroversial, and passionately held right recognized by all civilized people is that each of us owns our selves. In our time and place, where slavery has come to be seen as a moral outrage, each will expressing itself through a particular body is deemed to be the person who owns that body. Thus for example a medical researcher must obtain the consent of the subject because it is the subject's body

that is to be investigated, and the subject has one singular unambiguous right with respect to that body, the right to exclude others from all but trivial contact with it.

Consider the following thought experiment. Imagine that a large number of men (or alternatively women) were marooned with but a single woman (or alternatively man). Some might argue for a moral imperative to equal access to that singular sexual and procreative resource. I offer this scenario to show how extreme and far-fetched the example must be in order to generate even a hint of plausibility to the notion that a person's body could possibly be a communal asset. The extremis of the example highlights how very strong is our moral intuition that if anything in this world sits at the vertex of private property it is the human body and that each person owns their own.

Individual threats to the collective

Although the liberty and autonomy of the individual with respect to his own body sits at the center of our modern enlightened system of ethics, reasonable men recognize some limited collective rights with respect to the bodies of the persons who make up the collective. Consider incarceration, quarantine, conscription, and police searches and seizures of the body including even the bodily fluids of suspects. Each of these can be considered a collective right that the group takes in the body of some of its individual members. Each involves a serious breach of the liberty and autonomy interests of the individual by the collective.

The example most apposite to restrictions on genetic engineering is medical quarantine. A person is quarantined when organisms within his body pose a serious physical threat to the well-being of other members of the community. Quarantine, like all collective impositions on the private property rights that an individual has in his own body is an exception triggered by exceptional circumstances. Note also that quarantine, like the other impositions by the collective on the individual are not the privilege of every collective to which the individual can be ascribed, but rather of only one class of collective, the sovereign authority. Churches, ethnic groups, business associations, bowling leagues, linguistic groups, country clubs, and all the other varied collective entities that one might find oneself a part of are not recognized as having a right to incarcerate, quarantine, or conscript. At most they may exclude.

The right of the sovereign to quarantine is a constraint on the primary right that is

lodged in the individual. The constraint arises because the unconstrained action of the individual will constitute a substantial threat to the welfare of the group. Placing restraints on the individual's use of his body is in this respect a mere variation on the more general theme of restrictions on the use by the individual of other property over which he has dominion. Just as our right to own explosives and toxic materials does not mean that we are free to store or move them in any manner we choose, so too states and communities may quarantine people if they have a reasonable fear that the individual may be infected with a contagious disease. Because we each pose dangers to one another through the use of our property other than our bodies, such limitations on individual rights over one's property are so common that they are usually taken for granted, and not even recognized as a collective impingement on private property rights.

Germline Engineering.

Germline engineering is the process of 'artificially' and purposefully changing the genes of an organism such that when it procreates the changes replicate themselves in the next generation and - subject to the laws of genetics - in all future generations. The prospect of germline engineering has been fiercely criticized. Much of this criticism is directed at the 'un-natural' nature of this form of intervention. As an economist and a lawyer I am un-equipped to speak to the question of whether this process would be 'natural', and whether or not the answer to that question has any moral, and pari passu legal, weight. Instead I will address the question of harm and benefit.

Categories of Harm.

Three categories of harms have been ascribed to germline engineering. The first is a fear that prospective parents will simply make poor choices that harm the genetic inheritance of countless generations of their issue, that they will produce a phenotype that from the beginning is - or should be - seen as inferior to what would have otherwise naturally occurred. The second is some concern with inequalities (and therefore inequities?) in access to genetic advantages, that is, that germline engineering will not be available to all and so will allow some to provide their offspring with an 'unfair' advantage over others; and the third is a general concern with the integrity of 'the gene pool', that is, that the

variety of human genes will be reduced, thereby creating some prospective danger to human beings as a species. We shall examine each of these categories in turn by considering several hypothetical instances of germline engineering that might give rise to them.

Engineered Monsters.

The first category consists of parents intentionally choosing to genetically transform their progeny in a manner that the wider community considers harmful to the progeny. Consider the following:

Case 1: In China in the not too distant past mothers bound the feet of their infant daughters to stunt their growth. It was considered most attractive for a young woman to have a foot small enough to fit into the proverbial teacup. In addition it was a way for the Chinese to assert their national pride and to distinguish themselves from, and refuse to integrate with, the Mongol occupants. Imagine that some parents chose to genetically transform their female embryos to yield girls with tiny feet[1].

Case 2: Female circumcision (clitorectomy) is practiced in some Arab communities, with the effect, and for the apparent purpose of reducing the sexual satisfaction of women. Parents concerned that their daughters maintain their chastity might alternatively seek to genetically obstruct the development of the clitoris.

Case 3: Some writers have speculated that deaf parents might choose to have deaf children (Heller 2001, p. 165).

Note how almost frivolous and fanciful these illustrations appear. I did not try to make them so; it is simply very difficult to conceive of serious examples that satisfy this criterion. Why should that be so?

Mistreatment of children arises from two sources; bad motives, and bad judgment. The generic bad motive is selfishness; some parents care too little for their children and neglect them, and others use their children for their own narrowly selfish purposes and thereby abuse them.

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[1] The Salish Indians of the American Great Plains provide a parallel example. The Salish were commonly known as Flatheads because some of the neighboring tribes, believing that pointed heads were more elegant and attractive, bound the heads of their infants to change the shape. Presumably pointed heads could also be fostered by some sort of germline intervention.

Neglect finds no expression in germline engineering. If prospective parents do harm their offspring through germline engineering it is from the opposite of neglect, unwarranted meddling. But what of the analog to abuse? There is no analytic a priori reason why abuse can not find an expression in germline engineering. Just as parents might work their children to death, or rent them out to others, so too they might genetically engineer their germline for their own selfish benefit rather than that of their offspring. But even if evil prospective parents were to choose this path, it is more than a little difficult to conceive of how a third party would detect it. Even - perhaps especially - exploitative parents would choose genes for their children that make them as healthy, strong, vigorous, and intelligent as possible. Exploitive parents would want their child to be of the highest value - all the more to exploit![2] As long as the asset value of the child is maximized in the same markets where people operate to maximize their own value, the genetic choices of egregiously selfish prospective parents will be indistinguishable from those of selfless parents[3].

So disposing of bad motive, we are left with bad judgment; that is, prospective parents mistakenly making bad genetic choices for their offspring. What sorts of 'mistakes' might they make? We can gain some insight into this by first looking at the post-birth 'mistakes' that parents make. Some examples that come to mind are: (1) members of some religious groups refusing medical treatment for their children; or (2) not allowing their children to be educated beyond the 6th grade; or (3) as previously mentioned, female circumcision. What strikes one immediately is that such cases are far less common and public intervention is far more morally and politically problematic than cases of abuse and neglect motivated by selfishness. Why are they so rare, and problematic? And how does that inform the issue of germline manipulation?

Their rarity rests on our common humanity. Because of our genetic predispositions and our shared culture, if we care at all for our offspring, we have broadly similar goals for them. The reason that public intervention is so problematic even in those few cases where the goals of the parents are so at variance with the norm, is that respect for the prerogatives

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[2] By way of analogy note that slaves in the American south in the early 19th century had better diets and higher life expectancies than northern factory workers. The slaveowner, because he owned the capital asset of the slave, had a strong interest in maximizing its value.

[3] Consider in contrast the human breeding of cattle and chickens. Its purpose is to produce abundant, tender, tasty and inexpensive meat. Were that the motive for people to genetically transform their offspring, then just as there is a sharp divergence between the interests of the chickens and that of the chicken farmer as to the genetic endowment of the chickens, so too there would be one between the child and its parents.

of parenthood is a central cross-cultural value. So what does this imply for germline engineering?

First, egregiously bad genetic choices by prospective parents are likely to be trivial in number. As human beings, while we may differ markedly in some cultural characteristics, such as religion and language, we have evolved a set of values and tastes that are broadly similar; we all value health, we all value intelligence, and we have similar, albeit not identical, aesthetic tastes. To be more concrete and graphic, unlike many avian species our infants do not routinely engage in siblicide, and unlike a number of small mammals, human mothers do not routinely eat their young. Put simply, all human beings share a largely common human nature.

Second, because the moral range of germline engineering is less than that of the later socialization and upbringing of children, the number and variety of potentially offensive germline modifications will be still more limited; one can educate one's children in forbidden political philosophies and religions one can not engineer their genes to the same effect. Thus while the thesis that parents will seek to manipulate their germline so as to have children who are stupid and unhealthy violates no analytic a priori proposition, it does stretch the limits of plausibility.

That said, let us accept for the sake of argument that we are not dealing with an empty set, that is, that some prospective parents might chose to engineer their germline so as to have children with genetic characteristics that the wider community believes do not serve the offspring's interest, e.g. pointed heads, tiny feet, no clitoris, deafness. What then? Does the prospect of this danger require some supplementary regulation or prohibition?

Who is the proper judge of the interest of the as yet unborn child? The answer I offer without further argument in support is that it is the child herself. And there is the rub. The child is not there to express her considered judgment. Germline engineering is however not unique in presenting this difficult obstacle. Infants, small children, the mentally retarded, disturbed, and disabled are in much the same position as embryos. They similarly are not in a position to inform us of their preferences, to say nothing of a considered judgment of their interests. So whether a mother engineers the genes of the embryo that will become her daughter so that she is born with tiny feet, or alternatively binds her daughter's feet after birth, in both cases the embryo and child are too immature to express an opinion on the question. Someone else must offer the judgment and make the decision

for the child or future child.

As a general matter, who better than the parents to judge and represent the best interests of their prospective issue? We entrust parents with the power to make all manner of decisions that affect the future health, character, and personality of their children. What justifies this deference? Three bases suggest themselves. First, of all the adults who might exercise judgment on behalf of the child it is the parents who are most likely to have the child's interest at heart. Second, those who assume the duties of parenthood are entitled to some compensating privilege. And, third parents have a better sense of what is good for the child than the child does (Dworkin 2001, p. 153).

I see nothing that warrants a more intrusive policy for germline engineering. Indeed, there are three substantial reasons to allow greater deference to prospective parents in germline engineering of their embryos than to actual parents in post-birth choices for their children. First, there are fewer and less plausible base conflicts of interest (financial in particular) at play. Parents that refuse to expend resources on the education or health care of their extant child might claim to do so for religious reasons, but it also serves the parents own financial interests. A corresponding niggardly bent in the germline case would only result in declining to engage in germline engineering, rather than some disapproved choice of genotype.

Second, the earlier in the chain of events leading to the realization of personhood that one acts to change the outcome, the less the ultimate person affected has a claim against the actor as a matter of right. How else justify abortion? And why else distinguish late term from early term abortion? The germline engineering decision occurs at the earliest stage of the development of the human being when its ability and right to decide for itself is as limited as it could be, and furthermore the decision can not be postponed.

Parents do not own their children. Human beings are not property of anyone, even their parents. But parents are granted broad rights to the care and upbringing of their children. As the child matures the prerogatives of the parents diminish and the rights of the child increase. By extension back, the ‘child’ that is but a mere embryo, or a member of the even more inchoate future generations of offspring, are entitled to even less deference as against the judgment of the prospective parents. Thus in comparison to either male or female circumcision, genetic engineering to achieve the same result seems less morally problematic as a usurpation of the rights of another human being.

Third, if there are such things as fundamental rights that deserve heightened protection from state interference, and there is a hierarchy of those rights, then while child-rearing decisions fall well within the class, procreation must lie even closer to the center and deserve even greater deference. Procreation is a central primal act of not only human beings, not only primates, not only mammals, but of all living species. As such, the right to procreate or not is granted the broadest protection by, and deference from the state, e.g., constitutional rights to marry whom one chooses, acquire contraceptives, and abort pregnancies. Even those who carry known genetic defects are perfectly free not only to engage in sexual intercourse but to procreate without interference from the state. Whatever deference is appropriate to parental choices for their extant child with respect to circumcision (male or female), education, or religious training, an even greater deference is due to achieving those or other ends through procreative decisions.

So I conclude that the reason we can think of only the most bizarre and fanciful examples is that this category of potential harms is virtually a null set, and as for those few cases that might arise our best policy is tolerance and acceptance.

Inequitable Advantages.

We return now to the question of germline engineering. If the first objection to germline engineering is the concern that prospective parents will not do a good enough job representing their offsprings' interests, the second objection is its opposite, that they will do too good a job, that is, that they will provide their own offspring with a genetic advantage not available to others. To those morbidly fixated on the issue of equality this may seem a substantial problem.

Evaluating the potential harm of genetic manipulations that provide a benefit to some not made available to others requires a taxonomy that allows one to place each illustrative example into its own meaningful class. The first distinction that will have power to some readers is that between an equalizing transformation and an unequalizing one. Eliminating an inherited genetic disease would be equalizing, while fostering an immunity to colds is potentially unequalizing. The vast majority of human beings do not carry the gene for Huntington's disease. A germline intervention that eliminates this gene from those who carry it would be equalizing in that it would improve the lot of the minority and place then on a par with the majority. There can be no egalitarian objections to genetic

manipulation that benefits those worse off while causing no harm to those better off.

But what of unequalizing germline interventions? Imagine that it is possible to provide a genetic immunity to the viruses that cause the common cold. Is it acceptable for a minority of potential parents to purchase this for their offspring, or, alternatively, for the state to provide this to a minority of embryos? Whether we consider colds, intelligence, stature, strength, beauty or a host of other advantages that could potentially be fostered by germline manipulation, if only a minority of the population has access, a more dispersed distribution of positive human characteristics will result. Those who place a high premium on equality may find this objectionable.

But all unequalizing improvements (or for that matter equalizing ones) are not the same. They can further be classified by how the change in phenotype tangibly affects others not themselves subject to the genetic change. There are four possible economic classes arrayed along a scale moving from: (1) Pareto improving, through (2) social wealth increasing, to (3) social wealth neutral, and ending with (4) social wealth reducing.

A Pareto improving genetic transformation will make the subject better off while making no one else worse off, and more likely making them better off as well, though almost certainly yielding them less gain than that of the actual subjects of the genetic transformation. Examples of Pareto improvements from other spheres of life are legion. Consider the discovery of the polio vaccine. It brought fame and fortune to its discoverer Jonas Salk while at the same time protecting millions of children from a horrific disease. Everyone gained but some - especially Salk himself - gained more than others.

The second class is the social wealth increasing transformation. Some win, others lose, and the value of the gain to the winners (measured in monetary units) is greater than the loss to the losers. This class, along with the first (Pareto improving), are the engines of human progress. Consider the invention of the hand held calculator. It improved the welfare of all who made it, all who used it, and a legion of others who transacted with them. But not everyone gained. The advent of the calculator came at the cost of the livelihoods of those who had produced and skillfully used sliderules.

The third class consists of social wealth neutral changes. They benefit some but at an exactly (or nearly so) equal loss to others. Consider the effect of someone arriving early to purchase underpriced tickets for a concert or sporting event. Given that there are only a finite number of tickets on sale, the earlybird's gain is exactly the latecomer's loss.

The final class consists of changes that benefit some but at a greater cost to the rest of the population. Consider steroid use by competitive athletes. Assume that the goal is not an improved athletic performance per se, but defeating one's rivals. In some sense this is much like the previous example; my gain from the use of steroids (victory) is exactly your loss. But the health price paid by athletes who ingest steroids is high. Thus the net gain to those who indulge is less than the loss to those who abstain. Were all to take steroids and not change their relative performances all would lose from the availability and use of steroids.

While some will object on egalitarian grounds to all unequalizing germline manipulations regardless of which economic class they occupy, and others will object to none, most observers will favor those that appear in the earlier classes over those that appear in the later ones. So let us examine some illustrative cases of genetic modifications and consider which class they rightly occupy:

Case 4: fostering immunity to viruses that cause the common cold;

Case 5: increasing intelligence;

Case 6: increasing physical beauty in females;

Case 7: increasing aggression and selfishness in males.

These four examples are meant to imprecisely represent candidate cases respectively for each of the four classes discussed above - Pareto improving, social wealth increasing, social wealth neutral, and social wealth reducing. But as we will see, arguments are available - indeed I would, and will, make those arguments myself - in favor of placing each case in a different class. I am less concerned about persuading you of the proper placement of each case, than in illustrating the underlying principle that a genetic transformation could conceivably fall into each of the four, and in suggesting that widely held views on prohibition and regulation will turn on where a candidate germline intervention is believed to properly fit.

Let us begin with case 4, fostering immunity to the common cold. Such genetic immunity would not only be a great benefit to those whose genes are transformed, but would also profit those whose genes remain unchanged. It would reduce the quantity of viral matter spread by those around them. This is similar to the effect on one's likelihood of falling victim to polio if everyone else in one's community has been vaccinated against the disease; there are fewer hosts for the virus, and thus even those not immunized are far less

likely to contract the disease. Returning to the distinction I make in the first section of this essay, unless one believes that increased inequality is per se ‘evil’, even when it benefits all, I can conceive of no reason why anyone would object to a germline change that created immunity to the common cold.

Case 5 is germline intervention to increase intelligence. Intelligence to my way of thinking is a good unto itself, to be valued in its own right. But even if it is not, all the other forms of human wealth - all that humans create and then value - are built on the back of human intelligence. Were it not for our intelligence we would still be living like chimpanzees. It is beyond contravention that the more intelligent the population the larger the economic pie. It is likewise indisputable that as a general matter the greater one’s intelligence, the proportionally larger slice of the pie one can acquire (Herrnstein and Murray, 1994).

The more empirically difficult and perhaps ethically important question will be whether making one sub-group of the population more intelligent increases the size of ‘everyone's’ slice. I place ‘everyone’ in quotation marks to capture the ambiguity as to how many others, and which ones, need be hurt before we think we have crossed the fuzzy line between a merely social wealth increasing change and one that satisfies some less than absolute sense of Pareto improving - a standard that suffices as a matter of practical political and moral philosophy. That someone would not receive a chaired professorship in physics at M.I.T., and must settle instead for some slightly less grand position because there are now a spate of brilliant physicists generated by germline engineering, as a practical matter surely does not condemn us to the morally problematic universe of the social wealth increasing rather than the more pristine and exalted regions of the Pareto improving. In my view increasing human intelligence - even of a minority - would be the immensely powerful rising tide that would raise all ships with the possible and limited exception of the apocryphal un-chaired physics professor, and so is an unambiguous ex ante benefit to all.

I would go further and say that as a political and moral matter probably little rests on the distinction between Pareto improving and social wealth increasing forms of germline engineering. Does anyone have a right to their place in the genetic hierarchy? If not, then just as you would have no claim to seek an injunction to prevent me from providing my children with a superior education or better nutrition, so too you should have no claim to

prevent me from providing my children with more intelligence via superior genes.

Further, there is a common moral and political distinction, embodied in, and exemplified by, the jurisprudence of 'The Takings Clause' of the United States Constitution, between property, the taking of which entitles us to compensation, versus some mere expectation of future wealth if the world remains as it is for which no compensation is warranted. The physics chair at M.I.T. that you would have received but for the genetic enhancement of your rivals falls into the latter class rather than the former. So not only do those who would lose from the positional characteristic of this form of genetic enhancement of others have no right to prevent it, they are not even entitled to compensation.

As a general matter social wealth increasing changes, even if not strictly Pareto superior, should be strongly favored. Were this not the practice of our forefathers our lives would be primitive indeed. The great history of human advancement rests on the many millions of small social wealth increasing innovations that individually yielded gains to the winners only slightly larger than the losses to the losers; in the aggregate however they have yielded an enormous gain to all later generations. Consider, for example, each iteration of the ballpoint pen that drove prior manufacturers out of business and left unemployed resources in their wake. This Schumpeterian 'creative destruction' resulted to this point in the transformation of a messy extraordinarily expensive ($25 in 1945 dollars) novelty into an efficient, reliable, and inexpensive writing instrument.

Case 6 is genetically engineering more beautiful female offspring. I have suggested that this falls into the social wealth neutral class. That is, it would function much like arriving early to purchase tickets for a popular concert thereby precluding others from purchasing. The analogy rests on a notion that female beauty is essentially a currency employed in a zero sum game. Women compete for a fixed amount of attention (dates, marriage, etc) from men, and one woman's gain in this game is another's loss.

Undoubtedly, some readers will be offended by this example. Ironically, the illustrative power of the example is intimately tied to its contentious character. The propriety of using germline intervention to enhance the aesthetic appeal of women will turn for each of us on how we see the function of such appeal.

Plausible arguments can be given that such a germline transformation belongs more properly in the class below or the one above social wealth neutrality, or even in the earlier

grand category of parental error. Anyone persuaded of the applicability of the model of competition for a fixed resource - men's attention - might ask why this is not a negative sum game rather than a zero sum game. After all, we have presumed that such germline engineering is not available to all because it is costly. That cost must enter the utility calculus, and in doing so it transforms this competition into a substantially negative sum game. On the other hand, others might more fundamentally object to the assumption of an exclusively, or at least overwhelmingly, 'sexist' and sexual motivation for this genetic manipulation. Is not beauty a good in itself to be treasured and valued for itself? If so then such genetic enhancement will be social wealth increasing. And finally some will object to anyone participating in the female attractiveness competition on the grounds that it reinforces a pernicious view of women.

To repeat, the propriety of each particular instance of germline engineering will, for some, explicitly, and for many others, implicitly, turn on which category and class it properly occupies. But as this example reveals that placement in turn rest on the ontology of the judge, and there are abundant arguments - sensible and tendentious - available to cast a candidate in either a suspect or protected light.

Finally we have case 7, genetically engineering more aggressive and selfish men. In this case as in the one above the genetic transformation is ultimately motivated by a virtually universal 'desire' of all living organisms to spread their genes. Men who are more aggressive and selfish will for a variety of reasons generally be able to gain access to more women for procreation. In the simplest archetypical case they may simply violently displace a rival. Such increased aggression would lead to a more Hobbesian world, one that even Leviathan would find most difficult to productively manage. Each prospective parent's gain in creating an aggressive son imposes a significantly greater cost on the rest of the community. Here too one can make arguments that this depiction is too dismal, that an aggressive nature is a positive characteristic in enterprise and science. It is less important whether you agree that this particular case is properly placed in the bottom class, than that you are persuaded that it is at least a plausible candidate in the two senses that prospective parents might well choose such a transformation and it very well might be social wealth reducing. If so then we can agree that social wealth reducing germline interventions is not an a priori null set.

This last class and perhaps the one above are it seems to me plausible candidates for

not merely regulation, but even prohibition. Athletic governing bodies prohibit the use of anabolic steroids which have the effect of providing a competitive boost to some at the equal loss to others, all coming at a substantial price in health to the user. More generally societies employ a variety of legal and social institutions - tort law, criminal law, manners - designed to limit social wealth reducing activity. In that same spirit, so too might it ban social wealth reducing germline intervention.

Such a prohibition would in no way rest on germline intervention being unequally available. Indeed the case for prohibition is stronger if it is equally available, for then a ban on its use would be Pareto improving - all would gain!

Now let us look at these four cases and the four classes in which we have placed them as a whole. I think it not accidental that the examples in the first two classes seem much more plausible choices and scientific possibilities than those in the last two. More important, the former seem to be mere samples of a much broader universe of potential genetic manipulations, (e.g. after genetically creating an immunity to the common cold, we might add AIDS, and cancer) while the latter are quirky, tortured, sui generis special cases. The general point is that whatever policy we might have to deal with the social wealth reducing cases, I think we may rest assured that those potential germline interventions are a tiny proportion of the likely candidates.

There are two further observations I offer with regard to privately beneficial genetic changes: (1) in practice they are not likely to be as inegalitarian as some might fear; and (2) we already permit private decisions that yield far greater predictable equality reducing genetic outcomes. Germline manipulation will in the end be more egalitarian than it now appears for two reasons. First, and most important, like all technologies average costs will decline with volume, and learning. Just as modern technology has reduced the cost of food, ballpoint pens, the printed word, computers, and calculators, so too it will reduce the cost of germline engineering. And therefore just as books, which were once exclusively available to the super-rich, now may be purchased by all, so too germline engineering will before long become available to the mass of men. Second, germline engineering essentially consists of replacing protein bases with known successful alternatives. Those alternatives will be known because of the phenotypes they produce. Thus those with the most successful genetic structures will have the least to gain from germline engineering. Indeed, it will be their genes which will be copied.

The second point is that if some are truly troubled by the possibility of increasing genetic inequality generated by genetic engineering they should turn their attention to a far more powerful source of increasing genetic inequality, assortive mating. We are free to pick our own mates. Higher status men and women (however status is measured for each sex) tend to choose one another. Procreation through sexual intercourse allows us to not merely add a few favored alleles to the genetic mix of our offspring, but instead to combine an entire set of perhaps 34,000[4] genes with our own. And, we do this not at some substantial cost but as an ancillary benefit to the otherwise pleasurable act of lovemaking.

My brilliant friend David Friedman is the son of the Nobel prize winning economist Milton Friedman and his wife Rose (Director) Friedman, a woman of sterling intellectual ability in her own right[5]. David's intellectual brilliance is a direct result of the mating choices of his parents. Would anyone suggest that superior people not be permitted to procreate with one another? Such permissible voluntary activity does infinitely more to further genetic inequality in future generations than any conceivable germline manipulation. Germline manipulation will at most add trivially to this inequality. More likely, however, as I suggested above, given the expected rapid decline in the cost of genetic therapy over time, the ability to enhance the genetic virtues of one's offspring will become widely and cheaply available and thus serve to equalize our genetic endowment.

So I conclude this section by noting that it is precisely the improvement of the genetic makeup of people that is the great hope of germline engineering. Potential inequalities that might be exacerbated are: (1) trivial in number; (2) likely to nonetheless improve the welfare of those at the bottom of the distribution; (3) increase the wealth and well being of humanity as a whole; and (4) are swamped by the inequalities already generated by the marriage and procreative decisions of free people.

Endangering the gene pool.

The final, and most frightening objection to germline engineering is that it will result in some nightmarish metamorphosis of ‘the human gene pool’. I believe, to the contrary, that

[4] It was until recently believed that human beings carried perhaps 100,000 genes. The current estimate based on the results of the Human Genome Project suggests the number to be perhaps one-third of that (Venter 2001, p. 1304). The characterization of this as an estimate understates the uncertainty as to the number. The science of identifying a gene is still quite primitive.

[5] Rose Friedman's brother, Aaron Director, is one of the founding fathers of law & economics.

as with a literal nightmare, the danger is illusory.

The ‘human gene pool’ is nothing more than a wonderfully evocative metaphor for a rather mundane concept, i.e., the number of carriers of human genes capable of procreating and the variation in those genes across that population. Thus the size and character of the gene pool is measured along at least three dimensions: (1) the number of fertile gene carriers; (2) the variation in the genes they carry; and (3) the relative frequencies of the carriers of those variations.

The current size of the pool and the particular distribution of genes within the pool are neither durable nor sacrosanct. The human gene pool has been changing since time immemorial and will continue to do so in the future. The number of fertile carriers is essentially a linear function of the size of the human population, increasing in parallel over time, most dramatically in the last 200 years. The varieties of genes and their relative representation in the population have gone through a more ponderous and fundamental transformation. The very metamorphosis of a species of upright apes into human beings was nothing more than a shift of the central tendencies of a gene pool through natural and sexual selection.

Were there a virtue in preserving the current gene pool there would be no hope of doing so. It will change in the future - for good or ill - driven by the same forces that have brought it to its current state. Germline intervention, because of its limited practice in the foreseeable future, can have no more than a minor marginal effect on the pace and direction of change of the human gene pool.

But, looking unimaginably far into the human future and assuming for the sake of argument that germline engineering could have a major effect on the gene pool of the entire human race, of what consequence would those changes in the gene pool have for any one of us or our progeny? The impact of the gene pool on the welfare of any human being arises from two related sources. The principal one is a micro-concern. The gene pool presents each of us with better or worse prospects for a successful outcome to our efforts to procreate. More concretely, I am concerned that my two daughters and son find suitable mates, where suitability entails among other things some genetic characteristics that promise good health, intellectual achievement, physical vigor, and aesthetic appeal for their offspring. The gene pool sets the limits and likelihood of finding such a mate.

If much of the rest of the human race were to make systematically bad germline

choices then my children would have fewer potential suitable mates. But, it is hard to imagine that anyone - let alone everyone - will engineer germlines that result in changes of genotypes and phenotypes that I found so unappealing that I would reject those people as mates for my progeny.

But assuming the bizarre and unlikely, that others did make choices I found perverse, what then? The people and peoples of the world already differ in their genes and gene pools respectively to a far greater degree than could (in the foreseeable future) be brought about by genetic engineering. Does that significantly affect the procreation prospects of my children? Procreation is not a random process. Many people carry genes for bad health, stupidity and homeliness. Those people, generally, are themselves unhealthy, stupid, and homely, and so will be unattractive both as life mates and for their genetic prospects. But they are no threat to us, for none of us need mate with them. So, even if others made poor germline choices, the rest of us are on notice and may look elsewhere for mates.

Perhaps it is the second - macro - source of danger to the gene pool that we should fear. The ostensible danger is that a reduction in human genetic variety may leave us vulnerable to a cataclysmic health disaster. We are social animals. Germline changes that threaten the very survival of the human race would leave even the survivors in perilous circumstances. Advanced human civilization rests on specialization and exchange. A human society consisting of but 50,000 people, instead of the current 5,000,000,000 would revert to a primitive economic state.

But why should germline engineering lead to such a cataclysm? The notion is that a move toward ‘superior’ genes may pari passu, mean a move to genetic uniformity, and in the end threaten the robustness of the human race as an entity. Microorganisms (bacteria, viruses, and fungi) are constantly attacking human beings. We evolve immunities and the microorganisms evolve to undermine them. The great variety of human beings makes it more likely that there will always be a large saving remnant that by chance has a gene based immunity to AIDS or some other plague. Human genetic variation ensures that that remnant will be of sufficient size to preserve not only life, but civilization. The fear is that if germline transformation becomes universal the tendency will be to greater human uniformity and the result will be a human race that is significantly less biologically resilient and robust.

The potential for germline transformation to result in greater vulnerability to disease is not purely hypothetical. The full phenotypic implications of our genes are demonstrably more complicated than a simple worse to better continuum. Some genes provide a benefit in one environment and a cost in another. Consider the following two illustrations: sickle cell anemia, and melanin. Sickle cell anemia is a recessive genetic disorder; one must receive the gene from both parents to suffer it. At the same time, the gene, even if received from only one parent, grants immunity against malaria. Eliminating the gene, while wiping out sickle cell anemia, would increase vulnerability to malaria. The second illustration is the set of genes for the production of melanin in the skin. If for health reasons (greater absorption of vitamins through the skin), or aesthetic reasons human beings universally chose to genetically reduce melanin and therefore pigmentation in their offspring, it would leave them more vulnerable to skin cancer.

But these are known dangers. A more serious problem results from unknown dangers. Perhaps, for example, the gene that permits human susceptibility to the common cold also provides a partial immunity to some more serious affliction, which we will only discover after eliminating the valuable gene.

What answers are there to this threat to the gene pool from germline engineering? First, and probably most important, before germline engineering could so reduce genetic variety as to present a danger to the continuation of human civilization or even to the entire human gene pool, it would have to be nearly universal. That is a prospect so far in the future, if realizable at all, that it should raise no bar to any current steps down that trail. We are like someone planning a vacation to the Grand Canyon. A concerned friend tells us that if we walk to close to the edge of the canyon we face the danger of plummeting to our death. Exercising proper caution does not require that we cancel our vacation or even slow our drive, but rather that we enjoy the view and keep a safe distance from the edge when we arrive. Similarly, if in a thousand years the human race, having eliminated Tay-Sachs, Huntington's and a variety of other genetic diseases, and having raised average human intelligence, is confronted by the prospect of seriously challenging human genetic diversity it should face that problem with the tools then available, not stand in the path of genetic progress now.

Second, we should already recognize and appreciate the power of one tool that will be available to us. Germline engineering is nothing more than the technology of replacing a

sequenced string of four chemical bases. The process of germline transformation has no single direction to it. We can go back from whence we came and undo our mistakes in the germline - much as nature does.

Third, we should recognize that it will be human beings acting out of there own self-interest who will make use of germline engineering. A threat to human diversity is a threat to each individual human being. Why assume that the individual response to the threat to genetic diversity will be social wealth reducing? That is, why assume that it is in the interest of the race that diversity be increased, and yet in my interest that my offspring be like everyone else? The opposite is more likely the case; I have at least as much to gain from my offspring being different as does the race as a whole.

To illustrate, imagine that there is a choice of genes that leaves one susceptible to either sickle cell anemia or malaria, as more people chose immunity to malaria, more leave themselves vulnerable to sickle cell. The choices of others change the payoff matrix for me. As a potential disease threatens to wipe out a large portion of the population the payoff to my offspring if they survive increases - they get to inherit a larger portion of the world. Thus there is an increase in the expected wealth of those in the minority[6].

With respect to infectious diseases there is a further reason that as more people create genetic immunities for their offspring less incentive exists for others to follow. The fewer people who are susceptible to a disease the less probability that I who am susceptible will fall victim. This is much like the effect of, and response to, vaccination. When a large proportion of the population are vaccinated the incentive for me to follow diminishes; there are now many fewer people from whom I can catch the disease.

The general point is that there is no tragedy of the commons at play here. As individuals we have the power to make considered choices, and if preserving diversity is a good bet for the species it is an even better bet for each individual.

An Aside on Cloning.

Cloning has been much in the news of late both as a scientific matter and a bio-ethical one,

[6] In this particular case there is further advantage to being in the minority. The gene in question provides its benefits against malaria even in heterozygous state but only leaves one subject to sickle cell disease if both pair of alleles are present. Thus as the percentage of carriers falls the cost to me of carrying the gene (likelihood of passing on sickle cell disease to my children) falls while the gain (my immunity to malaria) stays the same.

Because it is a distant cousin of germline engineering I will offer a few words on its benefits and harms. Cloning is the process of artificially and purposefully replicating an organism. Therefore, while the prospect of cloning is driven by many of the same scientific discoveries and innovations as germline engineering, it presents a different and arguably narrower set of potential dangers. From an evolutionary perspective cloning is radically conservative. If successful, it creates no new genotype. Thus, unlike germline engineering, it can possibly provide a systematic advantage to a member of the next generation nor pollute the gene pool. The harm that cloning might cause comes in two forms. First, given its less than stellar record of success thus far when attempted on other species there is potential harm from failed attempts to clone humans. Second, there is a postulated harm to the clone of being a clone.

In the popular imagination cloning is some sort of Brave New World science fiction enterprise in which there are multiple copies made of some outstanding - or infamous - human being. Would that that were a real prospect! While the notion of cloning a hundred Hitlers made for an entertaining movie plot, it is not likely to hold an attraction even to hard-core Nazis. It is not that Nazis would not like to revive the Fuhrer, it is rather that only a total fool would believe that a clone of Hitler would inherit his political philosophy. As for cloning great geniuses that is a different matter. A newly born Mozart would inherit the same musical genius that allowed the first to compose a symphony at seven; a second Gauss would doubtless be a mathematical giant. And, neither would be limited to the accomplishments of their earlier representation; each could stand not only on their own shoulders, but on those of the geniuses of the past two centuries. And the new Mozart, Gauss, Einstein, Kant, Hume, or Smith need not enter the career of his predecessor, but could find expression for his genetic genius in any number of different fields. While some express horror at such a prospect I see no darkside to another hundred Mozarts, another five hundred Gausses, another thousand Einsteins, perhaps even a few more Cohens, both creating and procreating.

As attractive as I find the prospect the likelihood of this coming to be in a liberal democracy is practically nil. Each clone when born will be an autonomous human being entitled to all the rights of any other person. He will not be the property of anyone, certainly not the scientist who carried out the procedure. So where is the self-interest that would drive such an enterprise? Who would be willing to gratuitously gestate and rear such

a clone? Who would be willing to compensate others for doing so? It is hard to see where the private market for these clones would be.

The more likely demand for cloning has three sources that arise from the direct interests of those with a strong personal stake in the genetic material to be cloned. First, there are infertile couples who wish to create a genetic legacy. Particularly when both husband and wife are infertile the only way they can have a child genetically related to either of them is by cloning. Second, there are couples who wish to replicate a deceased child or other loved one. Third, there are people in medical need of genetically matched tissue. Their interest is exclusively, or principally, in using a clone as a means to harvest such tissue.

None of these motives are frivolous. It requires only a modest measure of imagination and sympathy to appreciate the longing. But that does not necessarily make cloning a sensible or a permissible choice. It is not sensible if the expected cost to the actor outweighs the expected benefit. And, perhaps it should not be permitted if the expected costs to all affected parties outweigh the benefits.

What are the potential dangers and harms of cloning? One set of harms turn on the unreliability of the process. Virtually all innovative medical procedures are risky and dangerous in the beginning. Based on the experience of attempted cloning of other species one can predict that there will be much failure before there is success. To the extent that the cost of failure only burdens the cloned person or their sponsor no public intervention is called for. In each case those directly affected will be in the best position to weigh the costs and benefits.

But what of the clone? Will they be harmed by failure? While complete failure to initiate biological life harms noone, the creation of a flawed being is another matter. The most serious hereditary defects usually result in spontaneous abortion, so let us consider that as emblematic of the harm of failure to the clone. What weight should be given to the interests of the aborted fetus? I can offer no definitive answer. Who knows the interest of the hypothetical fetus in the gamble of life and premature death? That said, I suggest that it would be dishonest for many readers to attach excessive weight to this loss. Honesty demands consistency. The costs one assigns to the harm to the fetus from a spontaneous abortion must be consistent with the costs to a fetus from intentional abortion and with the costs to a fetus from negligent and reckless pre-natal behavior by pregnant women. A fetus

is a fetus is a fetus. If harming or killing it carries weight, that weight does not change with the act that gave rise to the harm.

It has become the de facto law of the land in the United States and most Western countries that a mother has the unconditional right to cause the death of her unborn fetus virtually at any time prior to birth. Indeed she can have the price of this procedure paid by the state. And, of those who oppose abortion, none, but the most fanatical, would treat a woman who chooses to have an abortion as a murderer. They thereby imply that they do not really consider the fetus a complete person entitled to the full set of rights accorded to others. Given these widely shared sentiments with respect to abortion the death of the fetus can not carry much weight for most of us. And if there is a greater cost that flows from bad intention, remember that, unlike in the case of an intentional abortion, the purpose of cloning is to produce a living healthy infant. The death of the fetal-clone is not only unintended but directly opposed to the wishes of the parents.

To this point I have only discussed the cost associated with failure. What of success? Is the clone harmed by having been created? Some commentators have suggested that being a clone would be an awful burden. I am skeptical. We all enter this world with a particular genotype not of our choosing. Each of us, like George Bailey, might at some point wish that we had never been born. There seems no a priori reason to think that a clone would have any more reason for this sentiment than anyone else. It is disingenuous to not only wax poetic of some imagined burden on a person who happens to be a clone, but further to treat this burden as so serious as to warrant a prohibition. There is a gross inconsistency in condemning cloning for some imagined harm to being a clone, when at the same time the rest of humanity is free to copulate and procreate will/nilly, and as a result carelessly, negligently, and recklessly bring offspring into this world with severe medical, social, and economic disabilities. Note as well that if there is a particular psychological burden to being a clone, then identical twins experience much the same burden, the only difference being that clones are not coincident in time.

As for creating a clone for the purpose of harvesting the tissue that is a different matter. Here the purpose is not normal procreation, but rather the use of the clone as an instrument. Still, let us not be too quick to condemn. There is more than a little hypocrisy in condemning as wantonly immoral partially gestating a fetus and aborting it for the purpose of recovering transplant tissue to save a life or restore health and yet permit, indeed

compensate and encourage, the same abortion to save the mother the burden of pregnancy. Whether the intent is to abort at some pre-natal stage or allow the clone to become a person and then used as a source of donated tissue, e.g., bone marrow or a kidney, the taking of which does not severely compromise the health of the clone, the procedure is problematic and should perhaps not be condoned because it entails treating the clone as an instrumentality rather than (or in addition to) a person. But if such behavior is unacceptable it is not because of any peculiarity of cloning. A couple could seek to produce a non-cloned fetus/child for exactly the same reasons. The propriety of such a strategy whether with a clone or not turns on the questions of: (1) at what stage of fetal development does one constitute a person entitled to the respect and care of one's parents'; and (2) the level of sacrifice parents may impose on one child for the benefit of another.

Conclusion.

The concern about the human gene pool in particular, and the wider set of fears about germline engineering in general are puzzling. The central arguments to support them are extraordinarily weak. So why is there such strong objection and anxiety?

I believe this is merely a symptom and manifestation of a deeper unease. There is a pervasive sense of spiritual decay in modern society, and rightly or wrongly this is associated with technological advance. That association is not merely an artifact of temporal association, there is a causal connection. The great advances in technology derive from man's successful attempt to rationalize the world. The fundamental unease, I believe, is rooted in a deep sense that at least one central aspect of the world, our lives, is ultimately not rationally comprehensible. We have a suspicion that the attempt to rationally understand ourselves leads us away from, rather than closer to, a comprehension of what we are about.

Our sense of unease with the modern world translates to a nostalgia for an older, simpler time, when perhaps life was more complete and fulfilling. And so the fears about germline engineering are of a single piece with fears of nuclear energy, and computers. But the virtue or vice of germline engineering, like that of nuclear energy and computers before it must rest on its own feet, and not merely be implicitly condemned on quasi-religious grounds as one more evocative representation of the misguided arrogance of modern man having lost touch with his roots.

On whether we are indeed lost, I offer no opinion in this essay. Whether the great advances of science have resulted from this arrogance I yet again offer no opinion. But finally, if all these things are true, is it a bad thing that modern science has discovered vaccines against polio and smallpox and entire extended families of antibiotics and analgesics? Here I shall not equivocate. These discoveries are not bad. To the contrary they are immensely good; they relieve suffering, cure disease, and permit people to live out a normal life span. So too with germline engineering. It offers the prospect of relieving much human suffering and allowing more of us to fulfill our aspiration of having children who exceed ourselves by our own measures of human worth and value.

Further, as I have tried to demonstrate in this essay germline engineering presents us with only chimerical and fantastic dangers. Prohibition, and even mere regulation, of germline engineering, beyond that already extant for medical experimentation must of necessity result in delay and greater expense. This delay and expense in turn must result in those who would otherwise benefit from a miracle of genetic intervention instead having to do without.

One's genes are as much one's property as any other part of one's body. If there is a reason for the state to interfere with the free use of one's genes it rests on the same basis that the state restricts the use of any other private property; does that use do substantial uncompensated harm to others. I have tried to show that the potential of germline engineering to do such harm is extraordinarily small. Beyond that my hope was not merely to demonstrate that these dangers are imaginary, but in doing so to suggest that the entire category of claims to some new category of property requiring a new set of legal, moral or social rules is unjustified.

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